NASA Technical Memorandum 4483

Publications of the Exobiology Program for 1991

A Special Bibliography

The George Washington University
Washington, D.C.

NASA Office of Space Science and Applications
Washington, D.C.

National Aeronautics and
Space Administration

Office of Management

Scientific and Technical
Information Program

1993

Table of Contents

Introduction

The Exobiology Program, located within the Solar System Exploration Division, Office of Space Science and Applications of the National Aeronautics and Space Administration, is an integrated program designed to investigate and understand those processes related to the origin, evolution, and distribution of life in the universe.

This report contains a listing of 1991 publications resulting from research supported by the Exobiology Program. Our intent in compiling this bibliography is twofold: to provide the scientific community with an annual publication listing (as we have done since 1975) of current NASA-supported research in this field, and to stimulate the exchange of information and ideas among the scientists working in the different areas of the program.

The Exobiology Program is broad in scope, covering the following subject areas: **Cosmic Evolution of Biogenic Compounds, Prebiotic Evolution, Early Evolution of Life, Evolution of Advanced Life, Solar System Exploration, Exploration Exobiology, Search for Extraterrestrial Intelligence,** and **Planetary Protection.**

Cosmic Evolution of Biogenic Compounds focuses on understanding the cosmic history of the biogenic elements (C, H, N, O, P, S) and their compounds in the galaxy and early solar system and understanding the mechanisms of their incorporation (evolution) into organic compounds. This includes: (1) tracing the physical and chemical pathways of the biogenic elements and their compounds from their origins in stars to their incorporation in pre-planetary bodies; (2) determining the kinds of measurements that can be made on the biogenic elements and their compounds to develop theories about solar system formation and prebiotic evolution, and the origin of life; and (3) determining the ways in which the physical and chemical properties of the biogenic elements and their compounds may have influenced the course of events during the formation of the solar system and component bodies.

Prebiotic Evolution seeks to understand how the evolutionary sequence leading from simple chemicals to living systems occurred during the development of the Earth and other planets. Research and analysis falls into two major areas: (1) the consequences of planetary evolution on the physical environment of the Earth and planets, including the importance of the physical-chemical processes associated with the development of dynamic planetary surfaces, and (2) the evolution of molecules and molecular systems focusing on energetics, dynamics, and synthesis of chemicals and chemical systems to determine mechanisms by which these systems acquired biological attributes under the constraints imposed by the physical environment.

Early Evolution of Life focuses on the nature and history of primitive organisms, relating their evolution to those forces that shaped the evolution of the Earth. The evolutionary record occurs in two forms: the familiar fossil record in rocks, in which phylogeny is deduced from morphology, and in the genome of extant organisms, where mutational events, the driving force of evolution, are expressed in sequences found in the organism's nucleic acids, or the gene products. Thus, studies use the geological record and the molecular record in living organisms to determine when and in what setting life first appeared, to determine the characteristics of the first successful living organisms, to understand the phylogeny and physiology of primitive organisms, to understand the evolution of energy-transducing systems, and to understand what determines the rate of mutation (evolution).

Evolution of Advanced Life examines the influence of astrophysical, stellar, and solar system impact events on the evolution of advanced life on Earth, with specific regard to their role in species extinctions. Research in this area focuses on understanding the role of extinction in evolution and the physical conditions that cause extinction of species.

Cosmic Evolution of Biogenic Compounds

Allamandola*, L.J.
Analysis of frozen volatiles.
In: *ROSETTA/CNSR: A Comet-Nucleus Sample-Return Mission.* Paris: European Space Agency, p. 47-52, 1991. (ESA-SP-1125) (GWU 14444)

Allamandola*, L.J.
Interstellar organics and possible connections with the carbonaceous components of meteorites and IDPs (Abstract).
Meteoritics 26(4): 312-313, 1991. (GWU 15914)

Allamandola*, L.J.
The nature of interstellar/precometary ices.
In: *The Physics and Composition of Interstellar Matter* (Krelowski, J., Papaj, J., Eds.). Torun: Copernicus University Press, 1990.

Allamandola*, L.J.; Sandford, S.A.; Tielens, A.G.G.M.; Herbst, T.
Methanol in the sky with diamonds (Abstract).
Meteoritics 26(4): 313, 1991. (GWU 15913)

Allamandola*, L.J.; Sanford, S.A.; Schutte, W.A.; Tielens, A.G.G.M.
Laboratory and observational study of the interrelation of the carbonaceous component of interstellar dust and solar system materials (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 18, 1991. (NASA-CP-3129) (GWU 5894)

Anicich*, V.G.; Arakelian, T.; Hanner*, M.S.
Quantification of UV stimulated ice chemistry: CO and CO_2 (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 19, 1991. (NASA-CP-3129) (GWU 6495)

Banin*, A.; Blake*, D.F.; Benshlomo, T.
Detection of nanophase lepidocrocite (γ-FeOOH) in iron-smectite Mars soil analog materials (MarSAM) (Abstract).
Lunar and Planetary Science Conference XXII: 49-50, 1991. (GWU 15710)

Baron, R.; Joseph, R.D.; Owen*, T.; Tennyson, J.; Miller, S.; Ballester, G.E.
Imaging Jupiter's aurorae from H_3^+ emissions in the 3-4 μm band.
Nature 353(6344): 539-542, 1991. (GWU 11099)

Batllo, F.; LeRoy, R.C.; Parvin, K.; Freund*, F.; Freund, M.M.
Positive holes in magnesium oxide: Correlation between magnetic, electric, and dielectric anomalies.
Journal of Applied Physics 69(8): 6031-6033, 1991. (GWU 14875)

Batllo, F.; Desgranges, L.; Freund*, F.
Anomalous thermal expansion and large polaron conductivity in magnesium oxide single crystals (Abstract).
Eos. Transactions, American Geophysical Union 72(44, Suppl.): 529-530, 1991. (GWU 16095)

Bergin, E.A.; Goldsmith, P.F.; Snell, R.L.; Ungerechts, H. (Irvine, W.M. = P.I.)
Physical conditions along the Orion Molecular Cloud ridge (Abstract).
Bulletin of the American Astronomical Society 23(4): 1372, 1991. (GWU 15371)

Blake*, D.; Allamandola*, L.; Sandford, S.; Hudgins, D.; Freund*, F.
Clathrate hydrate formation in amorphous cometary ice analogs in vacuo.
Science 254: 548-551, 1991. (GWU 14903)

Fredericks, J.R.; Gibson*, E.K., Jr.; Hartmetz, C.P.
Trapped lunar volcanic gases within Apollo 15 glass spherules (Abstract).
Lunar and Planetary Science Conference XXII: 409-410, 1991. (GWU 12290)

Freund*, F.; Battlo, F.; LeRoy, R.C.
Electrical conductivity of olivine revisited (Abstract).
Eos. Transactions, American Geophysical Union 72(44, Suppl.): 529, 1991. (GWU 16096)

Freund*, F.; Batllo, F.; LeRoy, R.C.; Lersky, S.; Masuda, M.M.; Chang*, S.
Crystal-field-driven redox reactions: How common minerals split H_2O and CO_2 into reduced H_2 and C plus oxygen (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 112, 1991. (NASA-CP-3129) (GWU 14564)

Freund*, F.; Masuda, M.M.; Freund, M.M.
Highly mobile oxygen hole-type charge carriers in fused silica.
Journal of Materials Research 6(8): 1619-1622, 1991. (GWU 14874)

Gibson*, E.K., Jr.; Hartmetz, C.P.
Carbon-bearing phases and volatiles in interplanetary dust particles (Abstract).
Lunar and Planetary Science Conference XXII: 439-440, 1991. (GWU 12291)

Gibson*, E.K., Jr.; Hartmetz, C.P.
Volatiles in interplanetary dust particles and aerogels (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 20, 1991. (NASA-CP-3129) (GWU 14035)

Gibson, J.E.; Pillinger, C.T.; Gibson*, E.K., Jr.
Carbon content of silica aerogel: A material proposed as a medium for collection of cosmic dust grains (Abstract).
Lunar and Planetary Science Conference XXII: 441-442, 1991. (GWU 12288)

Griffith, C.A.; Owen*, T.; Wagener, R.
Titan's surface and troposphere, investigated with ground-based, near-infrared observations.
Icarus 93(2): 362-378, 1991. (GWU 15375)

Hartmetz, C.P.; Gibson*, E.K., Jr.; Blanford, G.E.
Analysis of volatiles present in interplanetary dust and stratospheric particles collected on large area collectors.
Proceedings of Lunar and Planetary Science 21: 557-567, 1991. (GWU 12287)

Hartmetz, C.P.; Gibson*, E.K., Jr.; Blanford, G.E.
In situ extraction and analysis of volatile elements and molecules from carbonaceous chondrites.
Proceedings of Lunar and Planetary Science 21: 527-539, 1991. (GWU 15955)

Herbst, E.; DeFrees*, D.J.; Talbi, D.; Pauzat, F.; Koch, W.; McLean, A.D.
Calculations on the rate of the ion-molecule reaction between NH_3^+ and H_2.
Journal of Chemical Physics 94(12): 7842-7849, 1991. (GWU 5924)

Hollis, J.M.; Snyder, L.E.; Ziurys, L.M.; McGonagle, D. (Irvine, W.M. = P.I.)
Interstellar HNO: Confirming the identification.
In: *Skylines* (Haschick, A.D., Ho, P.T.P., Eds.). San Francisco, CA: Astronomical Society of the Pacific, p. 407-412, 1991. (ASP Conference Series, Vol. 16) (GWU 15302)

Madden, S.C. (Irvine, W.M. = P.I.)
Results of a galactic survey for the ring molecule cyclopropenylidene (C_3H_2).
In: *Chemistry in Space* (Greenberg, J.M., Pirronello, V., Eds.). Dordrecht, The Netherlands: Kluwer Academic Publishers, p. 437-438, 1991. (GWU 15290)

McConville, P.; Reynolds, J.H.; Epstein*, S.; Roedder, E.
Implanted ^3He, ^4He, and Xe in further studies of diamonds from Western Australia.
Geochimica et Cosmochimica Acta 55(7): 1977-1989, 1991. (GWU 15052)

Minh, Y.C.; Brewer, M.K.; Irvine*, W.M.; Friberg, P.; Johansson, L.E.B.
Abundance and chemistry of interstellar $HOCO^+$.
Astronomy and Astrophysics 244: 470-476, 1991. (GWU 14756)

Minh, Y.C.; Irvine*, W.M.
Interstellar H_2S: Probe of grain surface chemistry.
In: *Chemistry in Space* (Greenberg, J.M., Pirronello, V., Eds.). Dordrecht, The Netherlands: Kluwer Academic Publishers, p. 435-436, 1991. (GWU 15263)

Minh, Y.C.; Irvine*, W.M.
Upper limits for the ethyl-cyanide abundances in TMC-1 and L134N: Chemical implications.
Astrophysics and Space Science 175: 165-169, 1991. (GWU 14754)

Minh, Y.C.; Irvine*, W.M.; Brewer, M.K.
H_2CS abundances and ortho-to-para ratios in interstellar clouds.
Astronomy and Astrophysics 244: 181-189, 1991. (GWU 14753)

Minh, Y.C.; Ziurys, L.M.; Irvine*, W.M.; McGonagle, D.
Abundances of hydrogen sulfide in star-forming regions.
Astrophysical Journal 366: 192-197, 1991. (GWU 14755)

Notesco, G.; Kleinfeld, I.; Laufer, D.; Bar-Nun, A. (Owen, T. = P.I.)
Gas release from comets.
Icarus 89: 411-413, 1991. (GWU 13846)

Ohishi, M.; Kawaguchi, K.; Kaifu, N.; Irvine*, W.M.; Minh, Y.C.; Yamamoto, S.; Saito, S.
The ortho to para ratio for ketene in TMC-1.
In: *Atoms, Ions, and Molecules: New Results in Spectral Line Astrophysics* (Haschick, A.D., Ho, P.T.P., Eds.). San Francisco, CA: Astronomical Society of the Pacific, p. 387-391, 1991. (ASP Conference Series, Vol. 16) (GWU 14861)

Ohishi, M.; Suzuki, H.; Ishikawa, S.-I.; Yamada, C.; Kanamori, H.; Irvine*, W.M.; Brown, R.D.; Godfrey, P.D.; Kaifu, N.
Detection of a new carbon-chain molecule, CCO.
Astrophysical Journal 380: L39-L42, 1991. (GWU 14758)

Owen*, T.; Bar-Nun, A.; Kleinfeld, I.
Cometary impacts on the early Earth: Evidence from heavy noble gases (Abstract).
Eos. Transactions, American Geophysical Union 72(44, Suppl.): 59, 1991. (GWU 16098)

Owen*, T.; Bar-Nun, A.; Kleinfeld, I.
Noble gases in terrestrial planets: Evidence for cometary impacts?
In: *Comets in the Post-Halley Era*, Volume 1 (Newburn, R.L., Jr., et al., Eds.). Dordrecht, The Netherlands: Kluwer Academic Publishers, p. 429-437, 1991. (GWU 13845)

Pauzat, F.; Ellinger, Y.; McLean, A.D. (DeFrees, D.J.; Loew, G.H. = P.I.)
Is interstellar detection of higher members of the linear radicals C_nCH and C_nN feasible?
Astrophysical Journal 369: L13-L16, 1991. (GWU 12309)

Stone, J.; Hutcheon, I.D.; Epstein*, S.; Wasserburg, G.J.
Si, C and N isotopes in SiC from Orgueil and Murchison: H- and He- burning components in presolar grains (Abstract).
Lunar and Planetary Science Conference XXII: 1337-1338, 1991. (GWU 15705)

Talbi, D.; DeFrees*, D.J.
Ab initio study of $C + H_3^+$ reactions.
Chemical Physics Letters 179(1,2): 165-168, 1991. (GWU 14899)

Talbi, D.; DeFrees*, D.J.; Egolf, D.A.; Herbst, E.
Calculations concerning the reaction $C + H_3^+ \rightarrow CH^+ + H_2$
Astrophysical Journal 374(1): 390-393, 1991. (GWU 7026)

Tarter*, J.; Saykally, R.
Measurement of the spectral signature of small carbon clusters at near and far infrared wavelengths (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 17, 1991. (NASA-CP-3129) (GWU 9080)

Tielens, A.G.G.M.; Allamandola*, L.J.; Sandford, S.A.
Laboratory, observational and theoretical studies of interstellar ices.
In: *Solid-State Astrophysics* (Bussoletti, E., Strazzulla, G., Eds.). Amsterdam, The Netherlands: North-Holland Publishing, p. 29-58, 1991. (GWU 14443)

Tielens, A.G.G.M.; Tokunaga, A.T.; Geballe, T.R.; Baas, F. (Allamandola, L.J. = P.I.)
Interstellar solid CO: Polar and nonpolar interstellar ices.
Astrophysical Journal 381: 181-199, 1991. (GWU 15973)

Trafton, L.M.; Lester, D.F.; Ramseyer, T.F.; Salama, F.; Sandford, S.A.; Allamandola*, L.J.
A new class of absorption feature in Io's near-infrared spectrum.
Icarus 89: 264-276, 1991. (GWU 14767)

Trice, J.P.; Becker, J.F.; Sauke, T.B.; Freund*, F.
Kinetic $^{12}C/^{13}C$ fractionation during isothermal degassing of arc-fusion grown magnesium oxide (Abstract).
Eos. Transactions, American Geophysical Union 72(44, Suppl.): 523, 1991. (GWU 16097)

Ungerechts, H.; Bergin, E.A.; Carpenter, J.; Goldsmith, P.F.; Irvine*, W.M.; Lovell, A.; McGonagle, D.; Schloerb, F.P.; Snell, R.L.
Chemical gradients in the Orion Molecular Cloud (Abstract).
Bulletin of the American Astronomical Society 23(4): 1372, 1991. (GWU 15370)

Villar, H.O.; Loew*, G.H.
Properties of selective type-I benzodiazepine receptor ligands.
International Journal of Quantum Chemistry S18: 131-149, 1991.

Watson, L.L.; Ihinger, P.D.; Epstein*, S.; Stolper*, E.M.
Hydrogen, carbon and oxygen isotopic composition of volatiles in Nakhla (Abstract).
Lunar and Planetary Science Conference XXII: 1473-1474, 1991. (GWU 15706)

Whang, E.-J.; Freund*, F.
Carbon segregation from calcium oxide single crystals (Abstract).
Eos. Transactions, American Geophysical Union 72(44, Suppl.): 530, 1991. (GWU 16094)

Prebiotic Evolution

Arrhenius*, G.
Sources and geochemical evolution of cyanide and formaldehyde (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 44, 1991. (NASA-CP-3129) (GWU 8943)

Barak, D.; Shibata, M.; Rein*, R.
Structural investigation of protein kinase C inhibitors.
Journal of Molecular Structure 230: 419-429, 1991. (GWU 14780)

Benkert, J.P.; Kerridge*, J.F.; Kim, J.S.; Kim, Y.; Marti, K.; Signer, P.; Wieler, R.
Evolution of isotopic signatures in lunar-regolith nitrogen: Noble gases and N in ilmenite grain-size fractions from regolith breccia 79035 (Abstract).
Lunar and Planetary Science Conference XXII: 85-86, 1991. (GWU 15707)

Betts, J.N.; Holland*, H.D.
The oxygen content of ocean bottom waters, the burial efficiency of organic carbon, and the regulation of atmospheric oxygen.
Palaeogeography, Palaeoclimatology, Palaeoecology 97: 5-18, 1991. (GWU 14773)

Bishop, J.L.; Pieters, C.M.; Edwards, J.O.; Coyne*, L.M.; Chang*, S.
Spectroscopic analyses of Fe and water in clays. A Martian surface weathering study (Abstract).
Lunar and Planetary Science Conference XXII: 107-108, 1991. (GWU 15708)

Blank, J.G.; Stolper*, E.M.; Zhang, Y.
Diffusion of CO_2 in rhyloitic melt (Abstract).
Eos. Transactions, American Geophysical Union 72(17, Suppl.): 312, 1991. (GWU 16105)

Chu, B.C.F.; Orgel*, L.E.
Binding of hairpin and dumbbell DNA to transcription factors.
Nucleic Acids Research 19(24): 6958, 1991. (GWU 14665)

Chyba, C.; Sagan*, C.
Electrical energy sources for organic synthesis on the early Earth.
Origins of Life and Evolution of the Biosphere 21: 3-17, 1991. (GWU 14820)

Chyba, C.F. (Sagan, C. = P.I.)
The heavy bombardment and the origins of life (Abstract).
Eos. Transactions, American Geophysical Union 72(44, Suppl.): 59, 1991. (GWU 14818)

Chyba, C.F.; Sagan*, C.; Brookshaw, L.; Thomas, P.J.
Terrestrial accretion of prebiotic volatiles and organic molecules during the heavy bombardment.
In: *Bioastronomy: The Search for Extraterrestrial Life—The Exploration Broadens* (Heidmann, J., Klein, M.J., Eds.). Berlin: Springer-Verlag, p. 149-154, 1991. (GWU 14819)

Chyba, C.F.; Sagan*, C.; Thomas, P.J.; Brookshaw, L.
Terrestrial production vs. extraterrestrial delivery of prebiotic organics to the early Earth (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 46, 1991. (NASA-CP-3129) (GWU 7666)

Coyne*, L.
Reflectance signature of trapped holes in montmorillonites using near infrared reflectance analysis (NIRA) and EPR. Paper presented at "Colloidal and Surface Chemistry of Clays," Amerian Chemical Society Symposium, Atlanta, GA, April 14-19, 1991.

Egli, M.; Williams, L.D.; Gao, Q.; Rich*, A.
Structure of the pure-spermine form of Z-DNA (magnesium free) at 1-Å resolution.
Biochemistry 30(48): 1388-1402, 1991. (GWU 14961)

Egli, M.; Williams, L.D.; Gao, Q.; Rich*, A.
X-ray crystal structures of nucleic acids and their complexes with mono and bis-intercalators (Abstract).
Journal of Biomolecular Structure and Dynamics 8(6): a047, 1991. (GWU 16006)

Ferris*, J.P.; Guillemin, J.C.
Photochemical reactions of cyanoacetylene and dicyanoacetylene: Possible processes in Titan's atmosphere (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 42, 1991. (NASA-CP-3129) (GWU 14162)

Fox*, S.W.
Nonrandom protein in prelife → life transition (Abstract).
In: *Abstracts, Annual Meeting of the American Association for the Advancement of Science*, Washington, DC, February 14-19, 1991, p. 67. (GWU 14853)

Fox*, S.W.
Origins of life and biomedicinals from thermal proteins (Abstract).
Abstract of paper presented at the 201st National Meeting of the American Chemical Society, Biopolymers Symposium, Atlanta, GA, April 18-19, 1991, 1 p. (GWU 15073)

Fox*, S.W.
Synthesis of life in the lab? Defining a protoliving system.
Quarterly Review of Biology 66(2): 181-185, 1991. (GWU 5908)

Fox*, S.W.; Bahn, P.R.
Self-sealing artificial skin comprising copoly-alpha-amino acid (Patent).
U.S. Patent No. 4,996,292, February 26, 1991.

Fox*, S.W.; Ruecknagel, P.; Braunitzer, G.
Molecular bases for unity and diversity in organic evolution (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 55, 1991. (NASA-CP-3129) (GWU 12307)

Gao, Q.; Williams, L.D.; Egli, M.; Rabinovich, D.; Chen, S.-L.; Quigley, G.J.; Rich*, A.
Drug-induced DNA repair: X-ray structure of a DNA-ditercalinium complex.
Proceedings of the National Academy of Sciences USA 88(6): 2422-2426, 1991. (GWU 15260)

Harada, K.; Orgel*, L.E.
The cyclization of arabinosyladenine-5'-phosphorimidazolide.
Journal of Molecular Evolution 32: 358-359, 1991. (GWU 12608)

Harang, E.A.; Baltscheffsky, H.; Deamer*, D.W.
Production of ATP and PPi in *R. rubrum* chromatophores using ferrocyanide illumination to produce chemiosmotic proton gradients (Abstract).
Biophysical Journal 59: 518a, 1991. (GWU 14854)

Hefti, F.; Junard, E.O.; Knüsel, B.; Strauss, W.L.; Strang, P.F.; Przybylski, A.; Vaughan, G.; Fox*, S.W.
Promotion of neuronal survival in vitro by thermal proteins and poly(dicarboxylic) amino acids.
Brain Research 541: 273-283, 1991. (GWU 12292)

Kanavarioti*, A.; Rosenbach, M.T.
Catalysis of hydrolysis and nucleophilic substitution at the P-N bond of phosphoimidazolide-activated nucleotides in phosphate buffers.
Journal of Organic Chemistry 56(4): 1513-1521, 1991. (GWU 14747)

Kang, C.-H.; Zhang, X.; Lockshin, C.; Wainwright, N.R.; Rich*, A.
The structural studies of endotoxin neutralizing protein (Abstract).
Journal of Biomolecular Structure and Dynamics 8(6): a097, 1991. (GWU 16001)

Kerridge*, J.F.
Interstellar precursors in synthesis of meteoritic organic matter (Abstract).
Meteoritics 26(4): 356-357, 1991. (GWU 14905)

Kerridge*, J.F.
Isotopic analysis of cometary organic matter.
Space Science Reviews 56(1-2): 177-184, 1991. (GWU 15257)

Kerridge*, J.F.
Isotopic constraints on the origin of meteoritic organic matter (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 37, 1991. (NASA-CP-3129) (GWU 13377)

Kerridge*, J.F.; Bochsler, P.; Eugster, O.; Geiss, J.
Modelling the evolution of N and $^{15}N/^{14}N$ in the lunar regolith (Abstract).
Lunar and Planetary Science Conference XXII: 711-712, 1991. (GWU 15709)

Khare*, B.N.; Thompson, W.R.; Cheng, L.; Sagan*, C.; Meisse, C.; Arakawa, E.T.; Matthews, C.N.
Optical properties of tholin from H_2O/C_2H_6 (6:1) ice, and comparison with Titan tholin, kerogen and meteoritic organics (Abstract).
Bulletin of the American Astronomical Society 23(3): 1186, 1991. (GWU 14814)

Khare*, B.N.; Thompson, W.R.; Sagan*, C.; Arakawa, E.T.; Miesse, C.; Gilmour, I.
Optical constants of kerogen from 0.15 to 40 μm: Comparison with meteoritic organics.
In: *Origin and Evolution of Interplanetary Dust* (Levasseur-Regourd, A.C., Hasegawa, H., Eds.). Dordrecht, The Netherlands: Kluwer Academic Publishers, p. 99-101, 1991. (GWU 14817)

Lacey*, J.C.; Thomas, R.D.; Staves, M.P.; Watkins, C.L.
Stereoselective formation of bis(α-aminoacyl) esters of 5'-AMP suggests a primitive peptide synthesizing system with a preference for L-amino acids.
Biochimica et Biophysica Acta 1076: 395-400, 1991. (GWU 12269)

Lacey*, J.C., Jr.
Chemistry of aminoacylation of 5'-AMP and the origin of protein synthesis (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 54, 1991. (NASA-CP-3129) (GWU 7383)

Landry, B.; Allen, M.; Yung*, Y.L.
Troposphere-stratosphere interactions in a one-dimensional model of Jovian photochemistry.
Icarus 89(2): 377-383, 1991. (GWU 15382)

Levine*, J.S.
The biosphere as a driver for global atmospheric change.
In: *Scientists on Gaia* (Schneider, S.H., Boston, P.J., Eds.). Cambridge, MA: MIT Press, p. 353-361, 1991. (GWU 14811)

Morowitz*, H.J.
A window in time for the first evolutionary radiation (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 58, 1991. (NASA-CP-3129) (GWU 9780)

Morowitz*, H.J.; Deamer*, D.W.; Smith, T.
Biogenesis as an evolutionary process.
Journal of Molecular Evolution 33: 207-208, 1991. (GWU 14043)

Ohishi, H.; Kunisawa, S.; van der Marel, G.; van Boom, J.H.; Rich*, A.; Wang, A.H.-J.; Tomita, K.-I.; Hakoshima, T.
Interaction between the left-handed Z-DNA and polyamine: The crystal structure of the $d(CG)_3$ and *N*-(2-aminoethyl)-1,4-diamino-butane complex.
FEBS Letters 284(2): 238-244, 1991. (GWU 15651)

Orgel*, L.E.
Template polymerization of nucleotide analogues (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 50, 1991. (NASA-CP-3129) (GWU 7858)

Oró*, J.
Origen y evolucion de la vida. (Spanish)
In: *Nuestros Origenes: El Universo, la Vida, el Hombre* (Fernandez-Rañada, A., Ed.). Spain: Fundacion Ramon Areces, p. 167-199, 1991.

Oro*, J.; Lazcano, A.
On the origin and early evolution of biological catalysis and other studies on chemical evolution (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 53, 1991. (NASA-CP-3129) (GWU 4209)

Oró*, J.; Mills, T.; Lazcano, A.
Comets and the formation of biochemical compounds on the primitive Earth: A reappraisal (Abstract).
In: *Abstracts of the Conference on Comets and the Origins and Evolution of Life*, University of Wisconsin-Eau Claire, September 30-October 4, 1991, p. 30.

Pohorille*, A.; Benjamin, I.
Molecular dynamics of phenol at the liquid-vapor interface of water.
Journal of Chemical Physics 94(8): 5599-5605, 1991. (GWU 14878)

Pohorille*, A.; Wilson, M.; MacElroy*, R.D.
Structure and functions of water-membrane interfaces and their role in proto-biological evolution (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 48, 1991. (NASA-CP-3129) (GWU 7093)

Ponnamperuma*, C.
Studies on the origin of the genetic code (Abstract).
In: *Abstracts, Annual Meeting of the American Association for the Advancement of Science*, Washington, DC, February 14-19, 1991, p. 67. (GWU 15338)

Ponnamperuma*, C.; Honda, Y.; Senaratne, N.; Hobish, M.K.; Heng, J.
A possible relationship between enantiomeric structure of an amino acid and its association with its anticodonic nucleotide (Abstract).
Abstracts of Papers of the American Chemical Society 201: 101-BIOT, 1991. (GWU 15070)

Scattergood*, T.W.; McKay*, C.P.; Borucki, W.J.; Giver, L.P.; Van Ghyseghem, H.; Parris, J.E.; Miller*, S.L.
Production of organic compounds in plasmas: A comparison among electric sparks, laser-induced plasmas and UV light (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 39, 1991. (NASA-CP-3129) (GWU 9157)

Shibata, M.; Zielinski, T.J.; Rein*, R.
A molecular dynamics study of the effect of G • T mispairs on the conformation of DNA in solution.
Biopolymers 31: 211-232, 1991. (GWU 12609)

Sokalski, W.A.; Lai, J.; Luo, N.; Sun, S.; Shibata, M.; Ornstein, R.; Rein*, R.
Ab initio study of the electrostatic multipole nature of torsional potentials in CH_3SSCH_3, CH_3SSH, and HOOH.
International Journal of Quantum Chemistry: Quantum Biology Symposium 18: 61-71, 1991. (GWU 14778)

Sokalski, W.A.; Shibata, M.; Barak, D.; Rein*, R.
Catalytic activity of aminoacyl tRNA synthetases and its implications for the origin of life. I. Aminoacyl adenylate formation in tyrosyl tRNA synthetase.
Journal of Molecular Evolution 33(5): 405-411, 1991. (GWU 5869)

Stolper*, E.; Newman, S.
The role of water in the petrogenesis of Mariana trough magmas (Abstract).
Eos. Transactions, American Geophysical Union 72(44, Suppl.): 239, 1991. (GWU 16102)

Stribling, R. (Deamer, D. = P.I.)
High-performance liquid chromatography of oligoguanylates at high pH.
Journal of Chromatography 538: 474-479, 1991. (GWU 14865)

Stribling, R.; Miller*, S.L.
Attempted nonenzymatic template-directed oligomerizations on a polyadenylic acid template: Implications for the nature of the first genetic material.
Journal of Molecular Evolution 32: 282-288, 1991. (GWU 14796)

Stribling, R.; Miller*, S.L.
Template-directed synthesis of oligonucleotides under eutectic conditions.
Journal of Molecular Evolution 32: 289-295, 1991. (GWU 14795)

Thompson, W.R.; Henry, T.J.; Schwartz, J.M.; Khare*, B.N.; Sagan*, C.
Plasma discharge in $N_2 + CH_4$ at low pressures: Experimental results and applications to Titan.
Icarus 90: 57-73, 1991. (GWU 14821)

Thompson, W.R.; Sagan*, C.
Titans's condensates and tholins: Surface interactions (Abstract).
Bulletin of the American Astronomical Society 23(3): 1186, 1991. (GWU 14816)

Usher*, D.A.; Kozlowski, M.; Zou, X.
Catalytic RNA and synthesis of the peptide bond (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 55, 1991. (NASA-CP-3129) (GWU 12617)

Valverde, V.; Lazcano, A.; Gariglio, P.; Oró*, J.
Interaccion de reverso transcriptasas virales con cationes divalentes. (Spanish)
In: *Resumenes del XXII Congreso Nacional de Microbiologia*, Acapulco, Mexico, May 21-24, 1991, p. 41.

Velasco, A.M.; Medrano, L.; Oró*, J.; Lazcano Araujo, A.
Caracterizacion de un sitio funcional conservado en reverso transcriptasas celulares y virales (Abstract). (Spanish)
Abstract of a paper presented at Resumenes del III Congreso Nacional de SIDA, Mexico, October 21-23, 1991.

Zhang, S.; Lockshin, C.; Herbert, A.; Winter, E.; Rich*, A.
Zuotein-1, a putative Z-DNA binding protein in yeast *Saccharomyces cerevisiae* (Abstract).
Journal of Biomolecular Structure and Dynamics 8(6): a266, 1991. (GWU 16004)

Zhang, X.; Kang, C.-H.; Rich*, A.
The structural studies of left-handed Z-DNA (Abstract).
Journal of Biomolecular Structure and Dynamics 8(6): a267, 1991. (GWU 16005)

Zhang, Y.; Stolper*, E.M.
Water diffusion in a basaltic melt.
Nature 351: 306-309, 1991. (GWU 15327)

Zhang, Y.; Stolper*, E.M.
Water diffusion in a basaltic melt (Abstract).
Eos. Transactions, American Geophysical Union 72(17, Suppl.): 312, 1991. (GWU 15324)

Zhang, Y.; Stolper*, E.M.; Wasserburg, G.J.
Diffusion of a multi-species component and its role in oxygen and water transport in silicates.
Earth and Planetary Science Letters 103: 228-240, 1991. (GWU 15325)

Zhang, Y.; Stolper*, E.M.; Wasserburg, G.J.
Diffusion of water in rhyolitic glasses.
Geochimica et Cosmochimica Acta 55: 441-456, 1991. (GWU 15326)

Early Evolution of Life

Allen, M.E.; Friedmann*, E.I.
Scanning electron microscopy of cryptoendolithic microorganisms in Antarctic rocks: Distribution along ecological gradients (Abstract).
In: *Abstracts, 91st Annual Meeting of the American Society for Microbiology*, Dallas, TX, 1991, p. 190. (GWU 14803)

Asmerom, Y.; Jacobsen, S.B.; Knoll*, A.H.; Butterfield, N.J.; Swett, K.
Strontium isotopic variations of Neoproterozoic seawater: Implications for crustal evolution.
Geochimica et Cosmochimica Acta 55(10): 2883-2894, 1991. (GWU 5926)

Awramik*, S.M.
Nonmarine stromatolites and the search for early life on Mars (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 77, 1991. (NASA-CP-3129) (GWU 14542)

Awramik*, S.M.; Kusky, T.M.; Vanyo, J.P.
Inclined stromatolites as recorders of geophysical data (Abstract).
Eos. Transactions, American Geophysical Union 72(17, Suppl.): 270, 1991. (GWU 16106)

Barth, A.L.; Stricker, J.A.; Margulis*, L.
Search for eukaryotic motility proteins in spirochetes: Immunological detection of a tektin-like protein in *Spirochaeta halophila*.
BioSystems 24: 313-319, 1991. (GWU 14781)

Bauer, J.E.; Haddad, R.I.; Des Marais*, D.J.
Method for determining stable isotope ratios of dissolved organic carbon in interstitial and other natural marine waters.
Marine Chemistry 33(4): 335-351, 1991. (GWU 5942)

Blankenship*, R.E.; Causgrove T.P.; Alden, R.G.; Trost, J.T.
Primary photochemistry in heliobacterial reaction centers (Abstract).
Abstract of a paper presented at the VII International Symposium on Photosynthetic Prokaryotes, Amherst, MA, July 21-26, 1991, Abstract No. 60B. (GWU 14826)

Blankenship*, R.E.; Causgrove, T.P.; Cheng, P.; Brune, D.C.; Trost, J.T.; Alden, R.G.
Energy transfer and trapping in green photosynthetic bacteria and heliobacteria (Abstract).
Abstract of a paper presented at the Fourth Congress of the European Society for Photobiology, Amsterdam, The Netherlands, September 1-6, 1991, Abstract No. S9-3. (GWU 14822)

Blankenship*, R.E.; Trost, J.; Causgrove, T.; Alden, R.; Brune, D.; Liebl, U.; Vermaas, W.
Heliobacterial reaction centers as models for photosystem (Abstract).
Photochemistry and Photobiology 53: 6S, 1991. (GWU 14827)

Buchanan*, B.B.
Regulation of CO_2 assimilation in oxygenic photosynthesis: The ferredoxin/thioredoxin system.
Archives of Biochemistry and Biophysics 288(1): 1-9, 1991. (GWU 14749)

Buchanan*, B.B.
Thioredoxin and evolution (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 65, 1991. (NASA-CP-3129) (GWU 14533)

Buchanan*, B.B.
Thioredoxins: Photosynthetic proteins as regulatory prototypes for nonphotosynthetic systems (Abstract).
Plant Physiology 96(1, Suppl.): 43, 1991. (GWU 11817)

Des Marais*, D.J.; Canfield*, D.E.
Have stromatolites recorded changes in atmospheric carbon dioxide levels? (Abstract)
Eos. Transactions, American Geophysical Union 72(17, Suppl.): 165, 1991. (GWU 14885)

Des Marais*, D.J.; Truesdell, A.H.
Carbon isotope geochemistry of individual hydrocarbons in springs and fumaroles of Yellowstone National Park, Wyoming (Abstract).
In: *Abstracts with Program, Geological Society of America*, Annual Meeting, San Diego, CA, 1991, p. A19. (GWU 14887)

Dracheva, S.; Williams, J.C.; Van Driessche, G.; Van Beeumen, J.J.; Blankenship*, R.E.
The primary structure of cytochrome *c*-554 from the green photosynthetic bacterium *Chloroflexus aurantiacus*.
Biochemistry 30(48): 11451-11458, 1991. (GWU 14963)

Eglinton, T.I.; Fry, B.D.; Freeman, K.H.; Hayes*, J.M.
Stable carbon isotopic composition of individual products from flash pyrolysis of kerogens (Abstract).
Abstracts of Papers of the American Chemical Society 201: 103-FUEL, 1991. (GWU 15071)

Fairchild, I.J.; Knoll*, A.H.; Swett, K.
Coastal lithofacies and biofacies associated with syndepositional dolomitization and silicifaction (Draken Formation, Upper Riphean, Svalbard).
Precambrian Research 53: 165-197, 1991. (GWU 1303)

Fox*, G.E.
Exploration of RNA structure spaces (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 52, 1991. (NASA-CP-3129) (GWU 12306)

Francois, L.M.; Walker*, J.C.G.
Modelling the Phanerozoic carbon cycle and climate: Constraints from the $^{87}Sr/^{86}Sr$ isotopic ratio of seawater (Abstract).
Eos. Transactions, American Geophysical Union 72(17, Suppl.): 158, 1991. (GWU 16107)

Freeman, K.H.; Hayes*, J.M.
The relationship between ^{13}C in organic carbon and atmospheric pCO_2 and estimation of pre-Miocene CO_2 levels (Abstract).
Eos. Transactions, American Geophysical Union 72(17, Suppl.): 166-167, 1991. (GWU 16108)

Freeman, K.H.; Wakeham, S.G.; Hayes*, J.M.
Predictive isotopic biogeochemistry of lipids from the Black Sea and Cariaco Trench (Abstract).
Abstracts of Papers of the American Chemical Society 201: 38-GEOC, 1991. (GWU 15065)

Friedmann*, E.I.; Ocampo-Friedmann, R.
Strategies of xerophytic algae (Abstract).
Journal of Phycology 27: 126, 1991. (GWU 14799)

Grant, S.W.F.; Knoll*, A.H.; Germs, G.J.B.
Probable calcified metaphytes in the latest Proterozoic Nama Group, Namibia: Origin, diagenesis, and implications.
Journal of Paleontology 65(1): 1-18, 1991. (GWU 5923)

Green, L.S.; Yee, B.C.; Buchanan*, B.B.; Kamide, K.; Sanada, Y.; Wada, K.
Ferredoxin and ferredoxin-NADP reductase from photosynthetic and nonphotosynthetic tissues of tomato.
Plant Physiology 96: 1207-1213, 1991. (GWU 14895)

Huppe, H.C.; Picaud, A.; Buchanan*, B.B.; Miginiac-Maslow, M.
Identification of an NADP/thioredoxin system in *Chlamydomonas reinhardtii*.
Planta 186: 115-121, 1991. (GWU 14750)

Jahnke*, L.L.
The effects of oxygen on the evolution of microbial membranes (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 62, 1991. (NASA-CP-3129) (GWU 14530)

Jasper, J.P.; Hayes*, J.M.; Prahl, F.G.
Photosynthetic fractionation of ^{13}C and estimates of pCO_2 on the scale of 10^3-10^8 years (Abstract).
Abstracts of Papers of the American Chemical Society 201: 37-GEOC, 1991. (GWU 15072)

Jasper, J.P.; Hayes*, J.M.; Prahl, F.G.; Mix, A.; Wakeham, S.G.; Crusius, J.; Anderson, R.F.
Isotopically-driven estimates of dissolved CO_2 and equilibrium pCO_2 from late Quaternary sedimentary records in the equatorial Pacific and Black Sea (Abstract).
Eos. Transactions, American Geophysical Union 72(44, Suppl.): 272, 1991. (GWU 16103)

Jasper, J.P.; Prahl, F.G.; Mix, A.; Hayes*, J.M.
Photosynthetic ^{13}C fractionation and estimated CO_2 levels in the eastern equatorial Pacific (MANOP Site C) at over the last 255,000 years (Abstract).
Eos. Transactions, American Geophysical Union 72(17, Suppl.): 167, 1991. (GWU 16110)

Jukes*, T.H.
Random Walking: Chimps, gorillas, orangs and us.
Journal of Molecular Evolution 32(1): 1-2, 1991. (GWU 15064)

Jukes*, T.H.
Early development of the neutral theory.
Perspectives in Biology and Medicine 34(4): 473-485, 1991. (GWU 15582)

Jukes*, T.H.
Mars as a new abode for microbial life.
Journal of Molecular Evolution 32: 355-357, 1991. (GWU 14911)

Jukes*, T.H.; Osawa, S.
Recent evidence for evolution of the genetic code.
In: *Evolution of Life: Fossils, Molecules, and Culture* (Osawa, S., Honjo, T., Eds.). Toyko: Springer-Verlag, p. 79-95, 1991. (GWU 15581)

Jurtshuk, R.J.; Blick, M.; Bresser, J.; Jurtshuk, P., Jr.; Fox*, G.E.
16S rRNA *in situ* hybridization technique for differentiating closely related gram positive organisms, *Bacillus polymyxa* and *Bacillus macerans* (Abstract).
In: *Abstracts, 91st Annual Meeting of the American Society for Microbiology*, Dallas, TX, 1991, p. 244. (GWU 15367)

Kasting*, J.F.
Box models for the evolution of atmospheric oxygen: An update.
Palaeogeography, Palaeoclimatology, Palaeoecology 97: 125-131, 1991. (GWU 14761)

Kasting*, J.F.
CO_2 condensation and the climate of early Mars.
Icarus 94: 1-13, 1991. (GWU 14760)

Lanyi*, J.K.
Archaebacterial rhodopsin sequences: Implications for evolution (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 64, 1991. (NASA-CP-3129) (GWU 14532)

Liebl, U.; Blankenship*, R.E.; Vermaas, W.F.J.
Cloning of the reaction center gene from *Heliobacillus mobilis* (Abstract).
Abstract of a paper presented at the VII International Symposium on Photosynthetic Prokaryotes, Amherst, MA, July 21-26, 1991, Abstract No. 8A. (GWU 14825)

Lowe*, D.; Byerly, G.
Powerline Road section across the central Barberton Greenstone Belt.
In: *Two Cratons and an Orogen* (Ashwal, L.D., Ed.). Johannesburg, South Africa: University of the Witwatersrand, p. 154-162, 1991. (IGCP Project 280) (GWU 14836)

Lowe*, D.R.
Geology of the Barberton Greenstone Belt: An overview.
In: *Two Cratons and an Orogen* (Ashwal, L.D., Ed.). Johannesburg, South Africa: University of the Witwatersrand, p. 47-58, 1991. (IGCP Project 280) (GWU 14833)

Lyons, W.B.; Des Marais*, D.J.
The stable isotope biogeochemistry of carbon and nitrogen in Lake Hoare, Antarctica (Abstract).
Eos. Transactions, American Geophysical Union 72(17, Suppl.): 109, 1991. (GWU 14888)

Marcus, F.; Chamberlain, S.H.; Chu, C.; Masiarz, F.R.; Shin, S.; Yee, B.C.; Buchanan*, B.B.
Plant thioredoxin *h*: An animal-like thioredoxin occurring in multiple cell compartments.
Archives of Biochemistry and Biophysics 287(1): 195-198, 1991. (GWU 9029)

Margulis*, L.
Big trouble in biology: Physiological autopoiesis versus mechanistic Neo-Darwinism.
In: *The Reality Club: Doing Science* (Brockman, J., Ed.). New York: Prentice Hall, p. 211-235, 1991. (GWU 12623)

Margulis*, L.
Come nasce la vita. (Italian)
In: *La Narrazione delle Origini: A Cura di Lorena Preta.* Roma-Bari, Italy: Gius. Laterza & Figli, p. 30-36, 1991. (GWU 15322)

Margulis*, L.
Gaia, a new look at the Earth's system.
In: *Technology, Development and the Global Environment* (Makofske, W.J., Horowitz, H., Karlin, E.F., McConnell, P., Eds.). Mahwah, NJ: Ramapo College, Institute for Environmental Studies, p. 299-305, 1991. (GWU 14784)

Margulis*, L.
Lynn Margulis on Gaia and garbage.
Gaian Science May/July: 11-12, 1991. (GWU 14792)

Margulis*, L.
Symbiogenesis and symbionticism.
In: *Symbiosis as a Source of Evolutionary Innovation: Speciation and Morphogenesis* (Margulis, L., Fester, R., Eds.). Cambridge, MA: MIT Press, p. 1-14, 1991. (GWU 15476)

Margulis* , L.
Symbiosis in evolution: Origins of cell motility.
In: *Evolution of Life. Fossils, Molecules, and Culture* (Osawa, S., Honjo, T., Eds.). Tokyo: Springer-Verlag, p. 305-324, 1991. (GWU 14788)

Olsen, G.J.; Larsen, N.; Woese*, C.R.
The ribosomal RNA database project.
Nucleic Acids Research 19(Suppl.): 2017-2021, 1991. (GWU 15650)

Paster, B.J.; Dewhirst, F.E.; Weisburg, W.G.; Tordoff, L.A.; Fraser, G.J.; Hespell, R.B.; Stanton, T.B.; Zablen, L.; Mandelco, L.; Woese*, C.R.
Phylogenetic analysis of the spirochetes.
Journal of Bacteriology 173(19): 6101-6109, 1991. (GWU 14667)

Popp, B.N.; Hayes*, J.M.; Chicarelli, M.I.; Eckardt, C.B.; Maxwell, J.R.
Carbon and nitrogen isotopic analyses of porphyrins from the Triassic Serpiano Oil Shale (Abstract).
Eos. Transactions, American Geophysical Union 72(17, Suppl.): 158, 1991. (GWU 16112)

Rau, G.H.; Froelich, P.N.; Takahashi, T.; Des Marais*, D.J.
Does sedimentary organic $\delta^{13}C$ record variations in Quaternary Ocean [CO_2 (aq)]?
Paleoceanography 6(3): 335-347, 1991. (GWU 14890)

Rau, G.H.; Takahashi, T.; Des Marais*, D.J.; Sullivan, C.W.
Particulate organic matter $\delta^{13}C$ variations across the Drake Passage.
Journal of Geophysical Research 98(C8): 15131-15135, 1991. (GWU 14889)

Rössler, D.; Ludwig, W.; Schleifer, K.H.; Lin, C.; McGill, T.J.; Wisotzkey, J.D.; Jurtshuk, P., Jr.; Fox*, G.E.
Phylogenetic diversity in the genus *Bacillus* as seen by 16S rRNA sequencing studies.
Systematic and Applied Microbiology 14(3): 266-269, 1991. (GWU 15051)

Sagan, D.; Margulis*, L.
Epilogue: The uncut self.
In: *Organism and the Origins of Self* (Tauber, A.I., Ed.). Dordrecht, The Netherlands: Kluwer Academic Publishers, p. 361-374, 1991. (GWU 14786)

Sagan, D.; Margulis*, L.
Gaia: A "good four-letter word."
Gaia Magazine 3: 4-6, 1991. (GWU 11280)

Schopf*, J.W.
Collapse of the Late Proterozoic ecosystem.
South African Journal of Geology 94(1): 33-43, 1991. (GWU 15316)

Schopf*, J.W.
Early Archean (~3.4 Ga) prokaryotic filaments from cherts of the Apex Basalt, Western Australia: The oldest cellularly preserved microfossils now known (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 72, 1991. (NASA-CP-3129) (GWU 14537)

Schopf*, J.W.
The oldest evidence of photosynthesis in the fossil record (Abstract).
Photochemistry and Photobiology 53(Suppl.): 5S-6S, 1991. (GWU 15946)

Stan-Lotter, H.; Bowman, E.J.; Hochstein*, L.I.
Relationship of the membrane ATPase from *Halobacterium saccharovorum* to vacuolar ATPases.
Archives of Biochemistry and Biophysics 284(1): 116-119, 1991. (GWU 5914)

Sulzner, M.; Stan-Lotter, H.; Hochstein*, L.I.
Nucleotide protectable labeling of SH groups in subunit I of the ATPase from *Halobacterium saccharovorum*.
In: *Abstracts, 91st Annual Meeting of the American Society for Microbiology*, Dallas, TX, 1991.

Váró, G.; Lanyi*, J.K.
Kinetic and spectroscopic evidence for an irreversible step between deprotonation and reprotonation of the Schiff base in the bacteriorhodopsin photocycle.
Biochemistry 30(20): 5008-5015, 1991. (GWU 7716)

Váró, G.; Lanyi*, J.K.
Thermodynamics and energy coupling in the bacteriorhodopsin photocycle.
Biochemistry 30(20): 5016-5022, 1991. (GWU 10988)

Walker*, J.C.G.
Degassing.
In: *Planetary Sciences: American and Soviet Research* (Donahue, T.M., Trivers, K.K., Abramson, D.M., Eds.). Washington, DC: National Academy Press, p. 191-202, 1991. (GWU 14805)

Walker*, J.C.G.
Feedback processes in the biogeochemical cycles of carbon.
In: *Scientists on Gaia* (Schneider, S.H., Boston, P.J., Eds.). Cambridge, MA: MIT Press, p. 183-190, 1991. (GWU 14806)

Whitmire, D.P.; Reynolds, R.T.; Kasting*, J.F.
Habitable zones for Earth-like planets around main sequence stars.
In: *Bioastronomy: The Search for Extraterrestrial Life—The Exploration Broadens* (Heidmann, J., Klein, M.J., Eds.). New York: Springer-Verlag, p. 173-178, 1991. (GWU 15331)

Wilson, M.M.; Liebl, U.; Blankenship*, R.E.; Vermaas, W.F.J.
Cloning of the reaction center gene from *Heliobacillus mobilis* (Abstract).
Abstract of a paper presented at the ISPMB Satellite Conference on Molecular Biology of Photosynthesis, Tempe, AZ, October 2-5, 1991, Abstract No. V-4. (GWU 14823)

Winker, S.; Woese*, C.R.
A definition of the domains *Archaea, Bacteria* and *Eucarya* in terms of small subunit ribosomal RNA characteristics.
Systematic and Applied Microbiology 14(4): 305-310, 1991. (GWU 14851)

Wisotzkey, J.D.; Jurtshuk, P., Jr.; Fox*, G.E.
16S rRNA phylogenetic relationships among the thermophilic *Bacillus* species (Abstract).
In: *Abstracts, 91st Annual Meeting of the American Society for Microbiology*, Dallas, TX, 1991, p. 244. (GWU 15368)

Woese*, C.R.
The use of ribosomal RNA in reconstructing evolutionary relationships among bacteria.
In: *Evolution at the Molecular Level* (Selander, R.K., Clark, A.G., Whittam, T.S., Eds.). Sunderland, MA: Sinauer Associates, p. 1-24, 1991. (GWU 15265)

Woese*, C.R.; Achenbach, L.; Rouviere, P.; Mandelco, L.
Archaeal phylogeny: Reexamination of the phylogenetic position of *Archaeoglobus fulgidus* in light of certain composition-induced artifacts.
Systematic and Applied Microbiology 14: 364-371, 1991. (GWU 14867)

Woese*, C.R.; Kandler, O.; Wheelis, M.L.
A natural classification.
Nature 351(6327): 528-529, 1991. (GWU 15369)

Evolution of Advanced Life

Alvarez, W.; Smit, J.; Anders, M.H.; Asaro*, F.; Maurrasse, F.J.-M.R.; Kastner, M.; Lowrie, W.
Impact-wave effects at the Cretaceous-Tertiary boundary in Gulf of Mexico DSDP cores (Abstract).
Lunar and Planetary Science Conference XXII: 17-18, 1991. (GWU 15711)

Asaro*, F.
Fine structure of the Late Eocene Ir anomaly in marine sediments (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 84, 1991. (NASA-CP-3129) (GWU 14545)

Briggs*, J.C.
A Cretaceous-Tertiary mass extinction? Were most of Earth's species killed off?
BioScience 41(9): 619-624, 1991. (GWU 14115)

Caldeira, K. (Rampino, M.R. = P.I.)
Continental-pelagic carbonate partitioning and the global carbonate-silicate cycle.
Geology 19: 204-206, 1991. (GWU 12665)

Caldeira, K.; Rampino*, M.R.
Carbon dioxide, global warming, and the mid-Cretaceous super plume (Abstract).
Eos. Transactions, American Geophysical Union 72(17, Suppl.): 301, 1991. (GWU 16113)

Caldeira, K.; Rampino*, M.R.
The mid-Cretaceous super plume, carbon dioxide, and global warming.
Geophysical Research Letters 18(6): 987-990, 1991. (GWU 12664)

Margolis, S.V.; Swinburne, N.H.M.; Alvarez, W.; McCauley, S.E.; Magde, L.S.; Donovan, J.; Snyder, D.; Asaro*, F.; Swisher, C.C.; McWilliams, M.; Hansen, H.J.; Pedersen, A.K.
Possible impact ejecta in the Paleocene flood basalt province of West Greenland (Abstract).
Eos. Transactions, American Geophysical Union 72(44, Suppl.): 278, 1991. (GWU 16104)

Rampino*, M.R.
Climatic impact of volcanic eruptions.
In: *Volcanism-Climate Interactions* (Walter, L.S., de Silva, S., Eds.). Greenbelt, MD: NASA, Goddard Space Flight Center, p. B/1-B/8, 1991. (NASA-CP-10062) (GWU 15297)

Rampino*, M.R.
Historical evidence for a connection between volcanic eruptions and climate change.
In: *Volcanism-Climate Interactions* (Walter, L.S., de Silva, S., Eds.). Greenbelt, MD: NASA, Goddard Space Flight Center, p. A/1-A/2, 1991. (NASA-CP-10062) (GWU 15298)

Rampino*, M.R.; Caldeira, K.G.
Biogeochemical modeling at mass extinction boundaries (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 88, 1991. (NASA-CP-3129) (GWU 14041)

Raup*, D.M.
Cumulative frequency distribution of past species extinctions (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 85, 1991. (NASA-CP-3129) (GWU 14040)

Raup*, D.M.
Extinction: Bad genes or bad luck?
New Scientist 1786: 46-49, 1991. (GWU 15645)

Solar System Exploration

Avanesov, G.; Zhukov, B.; Ziman, Ya.; Kostenko, V.; Kuzmin, A.; Murav'ev, V.; Fedotov, V.; Bonev, B.; Mishev, D.; Petkov, D.; Krumov, A.; Simeonov, S.; Boycheva, V.; Uzunov, Yu.; Weide, G.-G.; Halmann, D.; Pössel, W.; Head, J.; Murchie, S.; Schkuratov, Yu.G.; Berghänel, R.; Danz, M.; Mangoldt, T.; Pihan, U.; Weidlich, U.; Lumme, K.; Muinonen, K.; Peltoniemi, J.; Duxbury, T.; Murray, B.; Herkenhoff, K.; Fanale, F.; Irvine*, W.M.; Smith, B.
Results of TV imaging of Phobos (Experiment VSK-Fregat).
Planetary and Space Science 39(1/2): 281-295, 1991. (GWU 14902)

Carle*, G.C.; Kojiro*, D.R.; Oberbeck*, V.; O'Hara, B.J.; Pollack*, J.B.; Valentin*, J.R.; Bar-Nun, A.; Cohen, M.J.; Ferris*, J.P.; Greenberg, J.M.; Scattergood*, T.W.
Titan aerosol and gas experiment for the Huygens Probe (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 101, 1991. (NASA-CP-3129) (GWU 14555)

Courtin, R.; Wagener, R.; McKay*, C.P.; Caldwell, J.; Fricke, K.-H.; Raulin, F.; Bruston, P.
UV spectroscopy of Titan's atmosphere, planetary organic chemistry and prebiological synthesis. II. Interpretation of new IUE observations in the 220-335 nm range.
Icarus 90: 43-56, 1991. (GWU 14765)

Crisp, D.; Allen, D.A.; Grinspoon, D.H.; Pollack*, J.B.
The dark side of Venus: Near-infrared images and spectra from the Anglo-Australian Observatory.
Science 253: 1263-1266, 1991. (GWU 14896)

Griffiths, D.J.; Buettner, D.J.; Tsou*, P.
Effect of void-size distribution on the Hugoniot state at low shock pressures.
Journal of Applied Physics 70(9): 4790-4796, 1991. (GWU 15498)

Huntington*, J.L.; Schwartz*, D.E.; Marshall*, J.R.
Exobiological implications of dust aggregation in planetary atmospheres: An experiment for the Gas-Grain Simulation Facility (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 26, 1991. (NASA-CP-3129) (GWU 5897)

Irvine*, W.M.
Analysis of images obtained by the Phobos 2 spacecraft (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 100, 1991. (NASA-CP-3129) (GWU 14554)

Kojiro*, D.R.; Carle*, G.C.; Oberbeck*, V.R.; O'Hara, B.J.; Valentin*, J.R.; Scattergood*, T.W.; Cohen, M.J.
Analytical concepts for the in situ analysis of extraterrestrial environments (Abstract).
Abstracts of Papers of the American Chemical Society 201: 199-ANYL, 1991. (GWU 15067)

Kojiro*, D.R.; Cohen, M.J.; Stimac, R.M.; Wernlund, R.F.; Humphry, D.E.; Takeuchi, N.
Determination of C_1-C_4 alkanes by ion mobility spectrometry.
Analytical Chemistry 63: 2295-2300, 1991. (GWU 14873)

Kojiro*, D.R.; Cohen, M.J.; Wernlund, R.F.; Stimac, R.M.; Humphry, D.E.; Takeuchi, N.
Analysis of model Titan atmospheric components using ion mobility spectrometry (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 102, 1991. (NASA-CP-3129) (GWU 14556)

Kojiro*, D.R.; Woeller*, F.H.; Takeuchi, N.; Humphry, D.E.
A microvolume metastable ionization detector for the analysis of planetary atmospheres (Abstract).
Abstracts of Papers of the American Chemical Society 201: 198-ANYL, 1991. (GWU 15068)

Exploration Exobiology

Andersen, D.T.; McKay*, C.P.; Wharton*, R.A.; Sagan*, C.; Squyres, S.W.; Simmons, G.M.
"Life on Ice, Antarctica and Mars" (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 108, 1991. (NASA-CP-3129) (GWU 14560)

Banin*, A.; Orenberg*, J.; Roush*, T.
Spectroscopy and reactivity of mineral analogs of the martian soil (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 32, 1991. (NASA-CP-3129) (GWU 11477)

Baublis, J.A.; Wharton*, R.A., Jr.; Volz, P.A.
Diversity of micro-fungi in an Antarctic dry valley.
Journal of Basic Microbiology 31: 10-20, 1991. (GWU 14843)

Boston, P.J.; McKay*, C.P.
Subsurface microbial habitats on Mars (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 29, 1991. (NASA-CP-3129) (GWU 11475)

Davis, W.L.; Doyle, L.R.; Backman, D.E.; McKay*, C.P.
The habitability of Mars-like planets around main sequence stars.
In: *Bioastronomy: The Search for Extraterrestrial Life—The Exploration Broadens* (Heidmann, J., Klein, M.J., Eds.). Berlin: Springer-Verlag, p. 55-61, 1991. (GWU 14837)

Doyle, L.R.; McKay*, C.P.
Exobiological habitats: An overview.
In: *Bioastronomy: The Search for Extraterrestrial Life—The Exploration Broadens* (Heidmann, J., Klein, M.J., Eds.). Berlin: Springer-Verlag, p. 163-172, 1991. (GWU 14839)

Gwynne*, O.; McKay*, C.; Zubrin, R.
Human exploration of Mars.
Spaceflight 33(6): 208-212, 1991. (GWU 14763)

Harrison, A.A.; Clearwater, Y.A.; McKay*, C.P. (Eds.)
From Antarctica to Outer Space: Life in Isolation and Confinement. New York: Springer-Verlag, 410 p., 1991. (GWU 3256)

Mancinelli*, R.L.; Rothschild, L.J.; White, M.R.
Paleobiomarkers and defining exobiology experiments for future Mars experiments (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 30, 1991. (NASA-CP-3129) (GWU 11476)

Mancinelli*, R.L.; White, M.R.
Methylotroph activity in soil permeated with methane.
American Society of Microbiology I-45: 192, 1991.

Mancinelli*, R.L.; White, M.R.
Nitrogen fixation and denitrification in microbial mats inhabiting acid and thermal alkaline springs.
American Society of Microbiology I-46: 198, 1991.

McKay*, C.P.; Davis, W.L.
Duration of liquid water habitats on early Mars.
Icarus 90(2): 214-221, 1991. (GWU 5940)

Roush*, T.L.; Pollack*, J.B.; Orenberg*, J.B.
Derivation of mid-infrared (5-25μm) optical constants of some silicates and palagonite (Abstract).
Abstract of paper presented at the Workshop on Mars Sand and Dust, Tempe, AZ, February 4-5, 1991, 2 p.
(GWU 15077)

Schwartz, D.E.; Mancinelli*, R.L.; Kaneshiro, E.
Biologically controlled minerals as potential indicators of life (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 117, 1991. (NASA-CP-3129) (GWU 14569)

Schwartzkopf, S.H.; Mancinelli*, R.L.
Germination and growth of wheat in simulated Martian atmospheres.
Acta Astronautica 25(4): 245-247, 1991. (GWU 14880)

Squyres, S.W.; Andersen, D.W.; Nedell, S.S.; Wharton*, R.A., Jr.
Lake Hoare, Antarctica: Sedimentation through a thick perennial ice cover.
Sedimentology 38(2): 363-379, 1991. (GWU 5941)

Wharton*, R.A.; McKay*, C.P.; Clow, G.D.; Andersen, D.T.
Changes in ice-cover thickness and lake level of Lake Hoare, Antarctica: Implications for climatic change (Abstract).
Eos. Transactions, American Geophysical Union 72(17, Suppl.): 109, 1991. (GWU 15060)

Search for Extraterrestrial Intelligence (SETI)

Almar, I.; Calvin, W.H.; Rubtsov, V.V.; Sullivan, W.T., III; Tarter*, J.C.; Werthimer, D.J.
Selection criteria in bioastronomy: Excerpts from a panel discussion.
In: *Bioastronomy: The Search for Extraterrestrial Life—The Exploration Broadens* (Heidmann, J., Klein, M.J., Eds.). Berlin: Springer-Verlag, p. 393-401, 1991. (GWU 15336)

Betz*, A.
A directed search for extraterrestrial laser signals (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 96, 1991. (NASA-CP-3129) (GWU 14552)

Betz*, A.
A search for infrared laser signals.
Paper presented at the USA-USSR Joint Conference on The Search for Extraterrestrial Intelligent Life, Santa Cruz, CA, August 4-9, 1991, 6 p. (GWU 15911)

Billingham*, J.
Cultural aspects of SETI.
Paper presented at the 42nd Congress of the International Astronautical Federation, Montreal, Canada, October 7-11, 1991, 15 p. (IAF-91-609) (GWU 14838)

Billingham*, J.; Brocker*, D.H.
The NASA SETI Program (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 91, 1991. (NASA-CP-3129) (GWU 14547)

Billingham*, J.; Michaud, M.; Tarter*, J.
The Declaration of Principles for Activities Following the Detection of Extraterrestrial Intelligence.
In: *Bioastronomy: The Search for Extraterrestrial Life—The Exploration Broadens* (Heidmann, J., Klein, M.J., Eds.). Berlin: Springer-Verlag, p. 379-386, 1991. (GWU 15333)

Bixler, J.V.; Bowyer*, S.; Laget, M.
A high galactic latitude survey of far-ultraviolet excess objects.
Astronomy and Astrophysics 250(2): 370-388, 1991. (GWU 15381)

Bowyer*, C.S.; Werthimer, D.; Donnelly, C.; Herrick, W.; Lampton, M.
The SERENDIP II SETI project: Current status (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 94, 1991. (NASA-CP-3129) (GWU 14550)

Bowyer*, S.; Werthimer, D.; Donnelly, C.; Lampton, M.; Herrick, W.; Soller, J.; Ng, D.; Hiatt, T.
The SERENDIP SETI project.
Paper presented at the USA-USSR Joint Conference on The Search for Extraterrestrial Intelligent Life, Santa Cruz, CA, August 4-9, 1991, 8 p. (GWU 14871)

Cheung, K.-M.; Deutsch*, L.J.; Dolinar, S.J.; McEliece, R.J.; Pollara, F.; Shahshahani, M.; Swanson, L.
Recent advances in coding theory for near error-free communications.
In: *Technology 2000.* Washington, DC: NASA Headquarters, p. 229-241, 1991. (NASA-CP-3109, Vol. 2) (GWU 15291)

Cordes*, J.M.
Astrophysical masers as amplifiers of ETI signals.
Paper presented at the USA-USSR Joint Conference on The Search for Extraterrestrial Intelligent Life, Santa Cruz, CA, August 4-9, 1991, 9 p. (GWU 13832)

Flanagan*, M.J.
The behavior of quantization spectra as a function of signal-to-noise ratio.
In: *TDA Progress Report 42-107.* Pasadena, CA: NASA, Jet Propulsion Laboratory, p. 155-168, 1991. (GWU 15304)

Grimm*, M.J.; Zimmerman*, G.A.
Multimegapoint FFT's running on workstation computers.
In: *25th Annual Asilomar Conference on Signals, Systems, and Computers.* New York: IEEE Computer Society Press, p. 101-105, 1991. (GWU 15305)

Gulkis*, S.
Cosmic background radiation limits for SETI.
In: *Bioastronomy: The Search for Extraterrestrial Life—The Exploration Broadens* (Heidmann, J., Klein, M.J., Eds.). Berlin: Springer-Verlag, p. 269, 1991. (GWU 15330)

Heidmann, J.; Klein*, M.J. (Eds.)
Bioastronomy: The Search for Extraterrestrial Life—The Exploration Broadens. Berlin: Springer-Verlag, 430 p., 1991. (GWU 15074)

Hurwitz, M.; Bowyer*, S.; Martin, C.
The albedo and scattering phase function of interstellar dust and the diffuse background at far-ultraviolet wavelengths.
Astrophysical Journal 372: 167-184, 1991. (GWU 6314)

Kellermann, K.I.; Heeschen, D.; Backer, D.C.; Cohen, M.H.; Davis, M.; de Pater, I.; de Young, D.; Dulk, G.A.; Fisher, J.R.; Goss, W.M.; Haynes, M.P.; Heiles, C.E.; Irvine*, W.M.; Johnston, K.J.; Moran, J.; Ostro, S.J.; Palmer, P.; Phillips, T.G.; Rogers, A.E.E.; Scoville, N.Z.; Solomon, P.M.; Tarter*, J.C.; Taylor, J.H., Jr.; Thaddeus, P.; Uson, J.M.; Welch, W.J.; Wilson, R.W.
Radio astronomy.
In: *Working Papers: Astronomy and Astrophysics Panel Reports.* Washington, DC: National Academy Press, p. I/1-I/22, 1991. (GWU 16115)

Klein*, M.J.
NASA SETI Microwave Observing Project: Sky Survey element (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 93, 1991. (NASA-CP-3129) (GWU 14549)

Klein*, M.J.; Burns*, D.J.; Foster*, C.F.; Garyantes*, M.F.; Gulkis*, S.; Levin*, S.M.; Olsen*, E.T.; Wilck*, H.C.; Zimmerman*, G.A.
The NASA SETI Microwave Observing Project Sky Survey.
Paper presented at the USA-USSR Joint Conference on The Search for Extraterrestrial Intelligent Life, Santa Cruz, CA, August 4-9, 1991, 17 p. (GWU 15308)

Klein*, M.J.; Gulkis*, S.
The impact of technology on SETI.
In: *Bioastronomy: The Search for Extraterrestrial Life—The Exploration Broadens* (Heidmann, J., Klein, M.J., Eds.). Berlin: Springer-Verlag, p. 203-209, 1991. (GWU 15329)

Labov, S.E.; Bowyer*, S.
Spectral observations of the extreme ultraviolet background.
Astrophysical Journal 371(2): 810-819, 1991. (GWU 15373)

Levin*, S.; Asmar*, P.; Burns*, D.; Foster*, C.; Garyantes*, M.; Gosline*, R.; Gulkis*, S.; Klein*, M.; Olsen*, E.T.; Wilck*, H.; Zimmerman*, G.
Preliminary test data from the SETI Microwave Observing Project Sky Survey prototype.
Paper presented at the USA-USSR Joint Conference on The Search for Extraterrestrial Intelligent Life, Santa Cruz, CA, August 4-9, 1991, 7 p. (GWU 14868)

Planetary Protection

DeVincenzi*, D.L.
Planetary Protection issues and human exploration of Mars (Abstract).
In: *Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life* (Wharton, R.A., Jr., Andersen, D.T., Bzik, S.E., Rummel, J.D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 99, 1991. (NASA-CP-3129) (GWU 14553)

DeVincenzi*, D.L.; Klein*, H.P.; Bagby, J.R. (Eds.)
Planetary Protection Issues and Future Mars Missions. Moffett Field, CA: NASA, Ames Research Center, 64 p., 1991. (NASA-CP-10086) (GWU 14872)

Appendix

Principal Investigators

Louis J. Allamandola
NASA, Ames Research Center
Mail Stop 245-6
Moffett Field, CA 94035

Vincent Anicich
NASA, Jet Propulsion Laboratory
California Institute of Technology
4800 Oak Grove Drive
Pasadena, CA 91109

Gustaf Arrhenius
Scripps Institution of Oceanography
Mail Code A-020
University of California, San Diego
La Jolla, CA 92093

Frank Asaro
Lawrence Berkeley Laboratory
University of California
Berkeley, CA 94720

Stanley M. Awramik
Department of Geological Sciences
University of California
Santa Barbara, CA 93106

Amos Banin
San Francisco State University
Foundation
1640 Holloway Avenue
San Francisco, CA 94132

Albert Betz
Space Sciences Laboratory
University of California
Berkeley, CA 94720

John Billingham
NASA, Ames Research Center
Mail Stop 239-22
Moffett Field, CA 94035

David F. Blake
NASA, Ames Research Center
Planetary Biology Branch
Mail Stop 239-4
Moffett Field, CA 94035

Geoffrey A. Blake
Division of Geological
and Planetary Sciences
California Institute of Technology 17-25
Pasadena, CA 91125

Robert E. Blankenship
Center for the Study of Early Events
in Photosynthesis
Arizona State University
Tempe, AZ 85287

Stuart Bowyer
Department of Astronomy
Space Sciences Laboratory
University of California
Berkeley, CA 94720

John C. Briggs
1260 Julian Drive
Watkinsville, GA 30677

Bob Buchanan
College of Natural Resources
Department of Plant Biology
University of California
Berkeley, CA 94720

Theodore Bunch
NASA, Ames Research Center
Mail Stop 239-4
Moffett Field, CA 94035

Donald E. Canfield
Department of Earth
and Atmospheric Sciences
Georgia Institute of Technology
Atlanta, GA 30332

Glenn Carle
NASA, Ames Research Center
Mail Stop 239-12
Moffett Field, CA 94035

Sherwood Chang
NASA, Ames Research Center
Mail Stop 239-4
Moffett Field, CA 94035

Principal Investigators

Heinrich D. Holland
Department of Earth & Planetary Sciences
Hoffman Laboratory
Harvard University
20 Oxford Street
Cambridge, MA 02138

Marsha Hollander
Department of Chemistry
George Mason University
4400 University Drive
Fairfax, VA 22030

John R. Holloway
Departments of Chemistry and Geology
Arizona State University
Tempe, AZ 85287

William M. Irvine
Five College Radio Astronomy
Observatory
University of Massachusetts
619 Lederle Graduate Research Center
Amherst, MA 01003

Linda Jahnke
NASA, Ames Research Center
Mail Stop 239-4
Moffett Field, CA 94035

Thomas H. Jukes
Space Science Laboratory
University of California
6701 San Pablo Avenue
Oakland, CA 94608

Anastassia Kanavarioti
Department of Chemistry
University of California
Santa Cruz, CA 95064

James F. Kasting
Department of Geological Sciences
503 Deike Building
Pennsylvania State University
University Park, PA 16802

John F. Kerridge
Institute of Geophysics
and Planetary Physics
University of California
405 Hilgard Hall
Los Angeles, CA 90024

Bishun N. Khare
Laboratory for Planetary Studies
Center for Radiophysics
and Space Research
Space Sciences Building
Cornell University
Ithaca, NY 14853

Andrew H. Knoll
Botanical Museum
Harvard University
26 Oxford Street
Cambridge, MA 02138

Daniel R. Kojiro
NASA, Ames Research Center
Mail Stop 239-12
Moffett Field, CA 94035

Robert Kretsinger
Department of Biology
University of Virginia
Charlottesville, VA 22901

James C. Lacey, Jr.
Department of Biochemistry
Room 520 CHSB
University of Alabama
Birmingham, AL 35294

Janos K. Lanyi
Department of Physiology
and Biophysics
California College of Medicine
University of California
Irvine, CA 92717

James G. Lawless
NASA, Ames Research Center
Mail Stop 242-4
Moffett Field, CA 94035

Principal Investigators

Margaret Race
College of Natural Resources
101 Giannini Hall
University of California
Berkeley, CA 94720

Michael R. Rampino
Department of Applied Science
26-36 Stuyvesant Street
New York University
New York, NY 10003

David M. Raup
Department of Geophysical Sciences
University of Chicago
5734 South Ellis Avenue
Chicago, IL 60637

Robert Rein
Roswell Park Memorial Institute
Building CCC, Suite 218
666 Elm Street
Buffalo, NY 14263

Alexander Rich
Department of Biology
Massachusetts Institute of Technology
Cambridge, MA 02139

L.J. Rothschild
NASA, Ames Research Center
Mail Stop 245-3
Moffett Field, CA 94035

Jonathan Roughgarden
Department of Biological Sciences
Stanford University
Stanford, CA 94305

Ted L. Roush
NASA, Ames Research Center
Mail Stop 245-3
Moffett Field, CA 94035

John D. Rummel
Program Manager, Exobiology
NASA Headquarters
Code SBR
Washington, DC 20546

Carl Sagan
Center for Radiophysics
and Space Research
Laboratory for Planetary Studies
Space Sciences Building
Cornell University
Ithaca, NY 14853

Thomas Scattergood
NASA, Ames Research Center
Mail Stop 239-4
Moffett Field, CA 94035

J. William Schopf
Department of Earth & Space Sciences
3806 Geology Building
University of California
Los Angeles, CA 90024

J. John Sepkoski, Jr.
Department of Geophysical Sciences
University of Chicago
5734 South Ellis Avenue
Chicago, IL 60637

Thomas C. Shen
NASA, Ames Research Center
Mail Stop 239-12
Moffett Field, CA 94035

Edward M. Stolper
Professor of Geology
California Institute of Technology
Pasadena, CA 91125

Jill Tarter
NASA, Ames Research Center
Mail Stop 239-22
Moffett Field, CA 94035

Peter Tsou
California Institute of Technology
NASA, Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109

David Usher
Department of Chemistry
Baker Laboratory
Cornell University
Ithaca, NY 14853

Principal Investigators

SETI Investigators

NASA, Ames Research Center
SETI Project
Mail Stop 244-11
Moffett Field, CA 94035

Peter Backus
David H. Brocker
D. Kent Cullers
L.J. Deutsch
John Dreher
Chris Hlavka
J.L. Huntington
Jane Jordan
J.R. Marshall
D.E. Schwartz
Richard Stauduhar
L.D. Webster

NASA, Jet Propulsion Laboratory
SETI Program
California Institute of Technology
4800 Oak Grove Drive
Pasadena, CA 91109

P. Asmar
D.J. Burns
M.J. Flanagan
C.F. Foster
M.F. Garyantes
R. Gosline
M.J. Grimm
Samuel Gulkis
E.B. Jackson
Michael J. Klein
S.M. Levin
E.T. Olsen
H.C. Wilck
G.A. Zimmerman